Beam-gas background in LumiCals
a very first study

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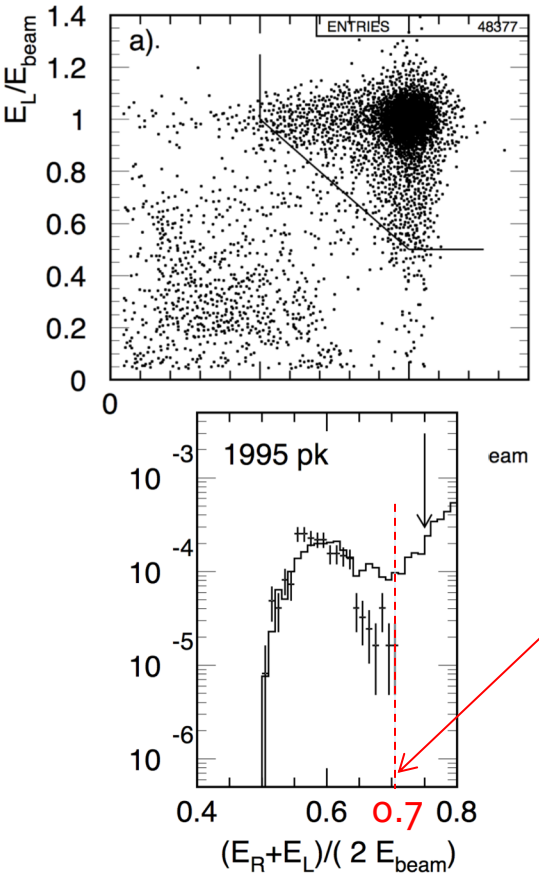
Off-momentum particles

Experience from OPAL @ LEP

The primary source of background to the luminosity measurement is from off-momentum electrons and positrons generated by beam-gas scattering in the straight RF sections on either side of the experiment which are deflected by the mini-beta quadrupoles into the luminosity monitor. The size of this background varies with time, and depends on the quality of the vacuum in the straight sections on either side of the OPAL interaction region and on the settings of the LEP collimators.



Probability of a cluster of E > 1 GeV to be found per BX

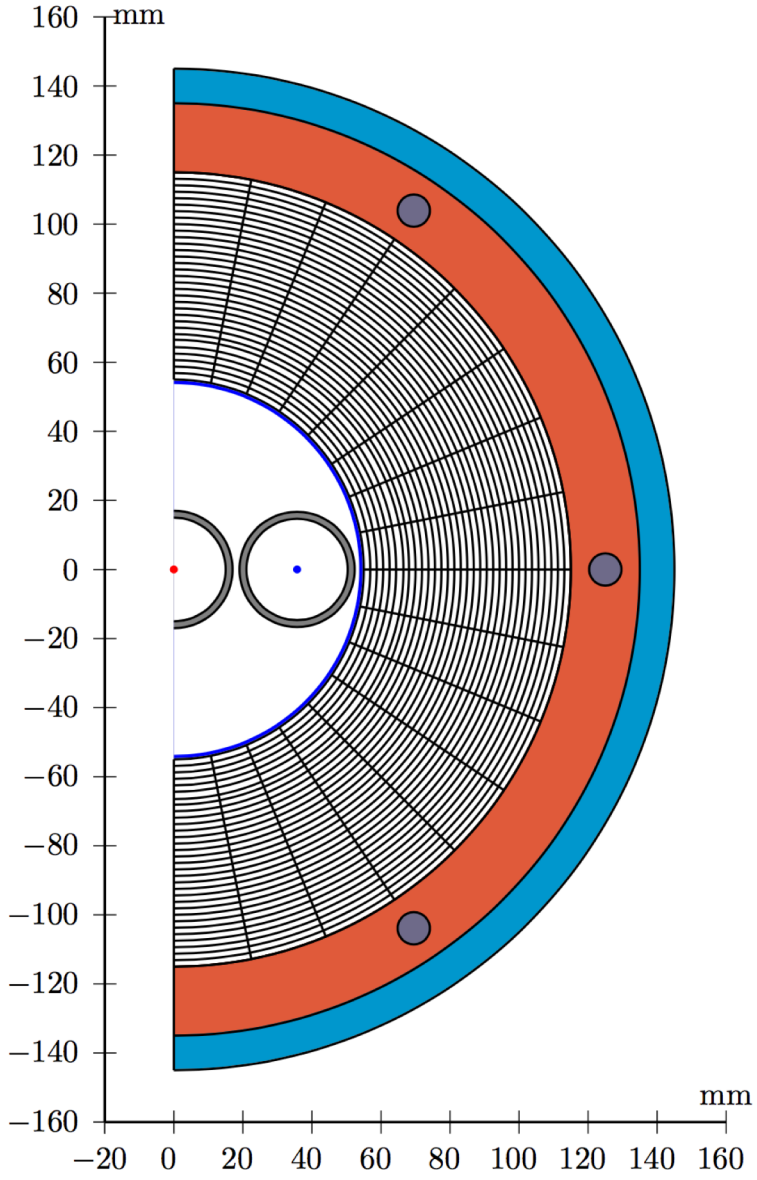
calorimeter	1993	1994	1995
right	8.0×10^{-3}	5.1×10^{-3}	8.4×10^{-3}
left	5.1×10^{-3}	3.7×10^{-3}	6.2×10^{-3}

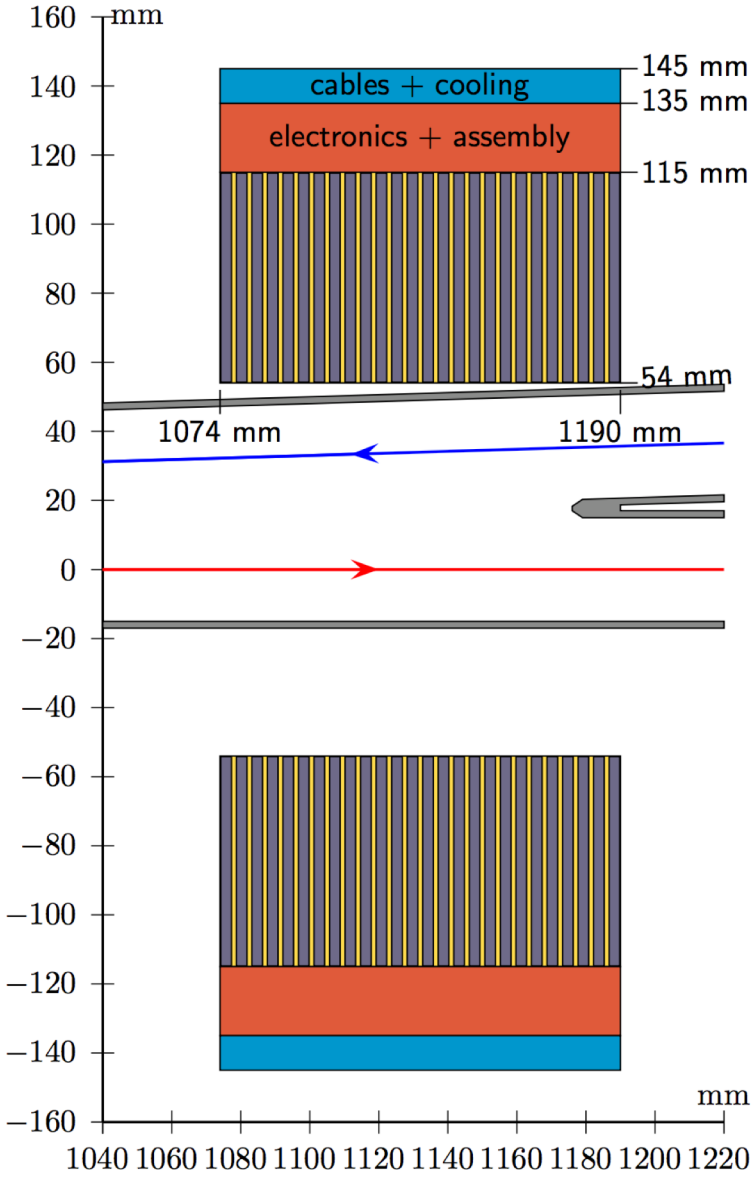
Probability of coincidence: **~5 x 10^{-5}**

- Comparable to rate of Bhabha events
- Reduced to 0.1-0-15 x 10^{-4} by cuts (energy, angle, …)

- 100 times higher off-momentum than Bhabha rate into calorimeters
  - ~50 x more deposited energy from off-momentum

Reminder: LumiCal Design





fcceez213mdi_BeamGas_Zabs_lt_2p1.dat

File from the simulation of inelastic Beam Gas scattering with N_2 in the MDI region of FCC-ee at the Z-pole energy, 45.6GeV, lattice version 213.
The distribution has been cut to |z|< 2.1m.

Beam1 circulates from negative to positive X and Z, with a crossing angle of 15mrad.

ASCII format, 157kB, 1074 lines, one event per line
15 columns separated by spaces.
Reference system at the IP (x=0,y=0,z=0)

Beam-gas generation form Oscar Blanco

Column	Units	Description
01) EventID	–	Event ID number
02) XBG	m	X position when interacting with Beam Gas
03) YBG	m	Y ''
04) ZBG	m	Z ''
05) EneBG	GeV	Energy loss in the interaction with Beam Gas
06) Xexit	m	X position when hitting the beam pipe
07) Yexit	m	Y ''
08) Zexit	m	Z ''
09) XPreexit	m	X position one step before hitting the pipe
10) YPreexit	m	Y ''
11) ZPreexit	m	Z ''
12) Cxexit	–	Cos of the momentum along X
13) Cyexit	–	'' Y
14) CZexit	–	'' Z
15) EneExit	GeV	Particle Energy when hitting the pipe

fcceez213mdi_BeamGas_Zabs_lt_2p1.dat

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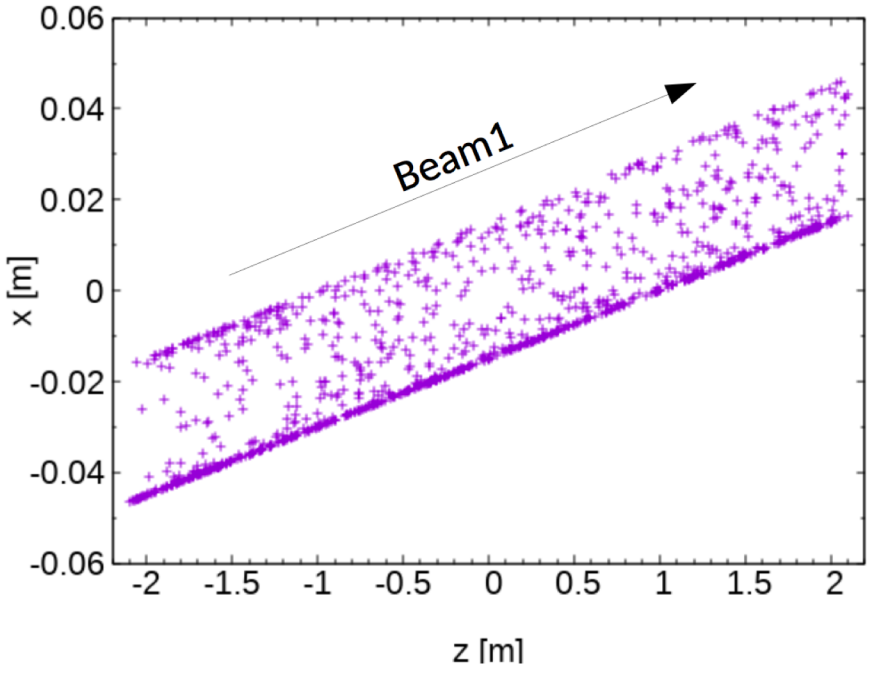
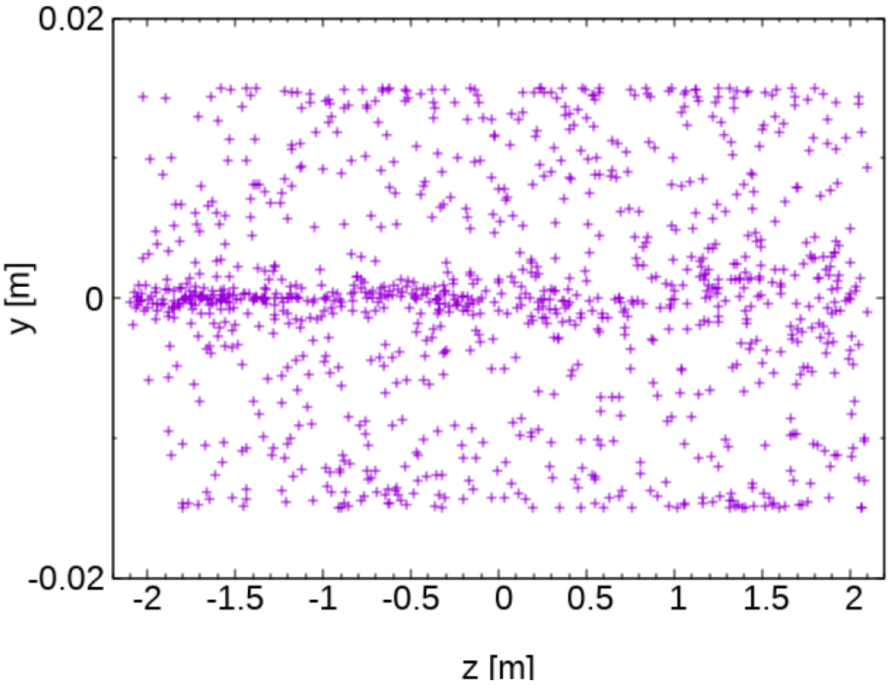
TOP view of the particles



SIDE view of the particles



fcceez213mdi_BeamGas_Zabs_lt_2p1.dat

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NORMALIZATION OF RATES

The number of events in the simulation can be normalized to give the loss rate at a pressure of 10^{-9} mbar of N_2 at 300K, using the expression

$$\text{Loss Rate [Hz/beam]} = \text{Nevents} \times 1.909 \times 10^{3}$$

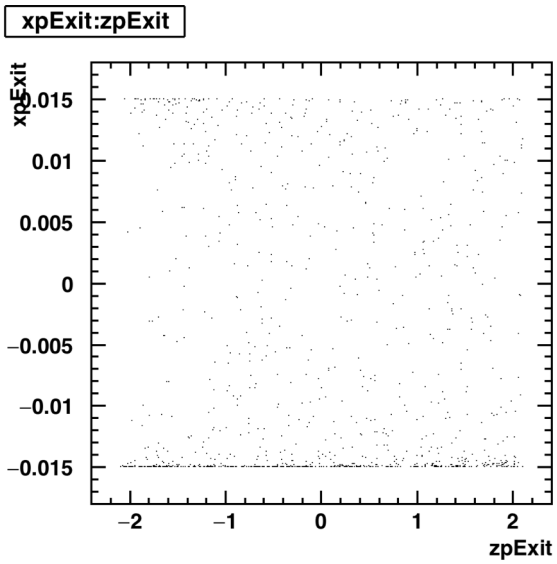
for the current parameters for the Z-pole :
Nparticles : 1.7×10^{11}
Nbunches : 16640

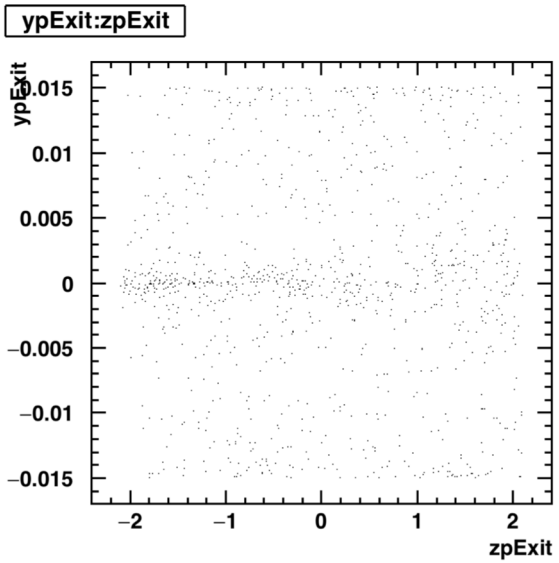
e.g. The 1074 events in the region -2.1m<z<2.1m in the simulation correspond to a

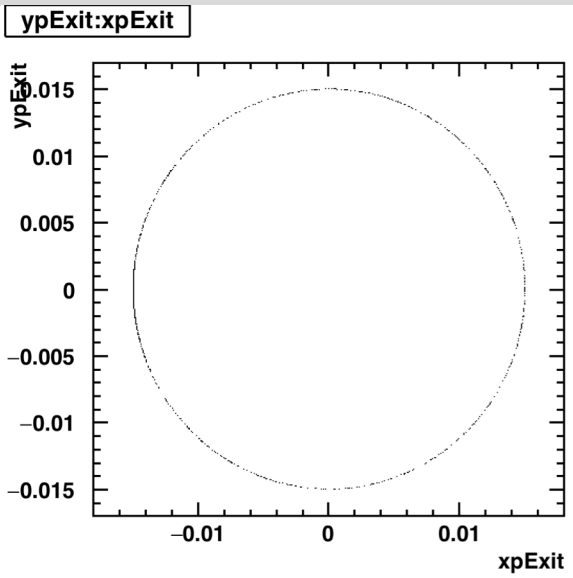
Loss Rate = 2.05MHz/beam @10^{-9} mbar of N_2 at 300K along 4.2m

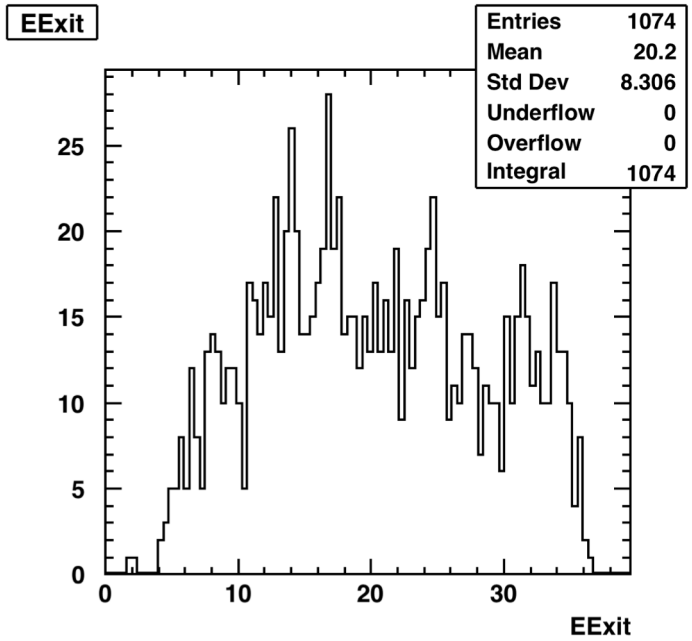
- Probability of off momentum particle per BX: 2.05 MHz / 50 MHz = 0.04
- Probability of two-arm coincidence: $0.04^2 =$ **1.6×10^{-3}**
- Comparable to Bhabha probability: **6.4×10^{-4}**

Go to LumiCal centered coord syst



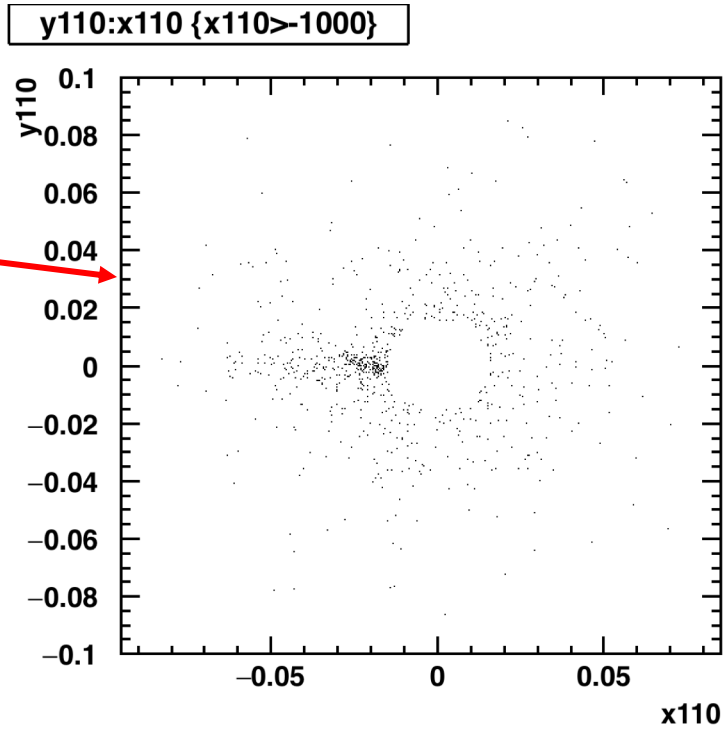


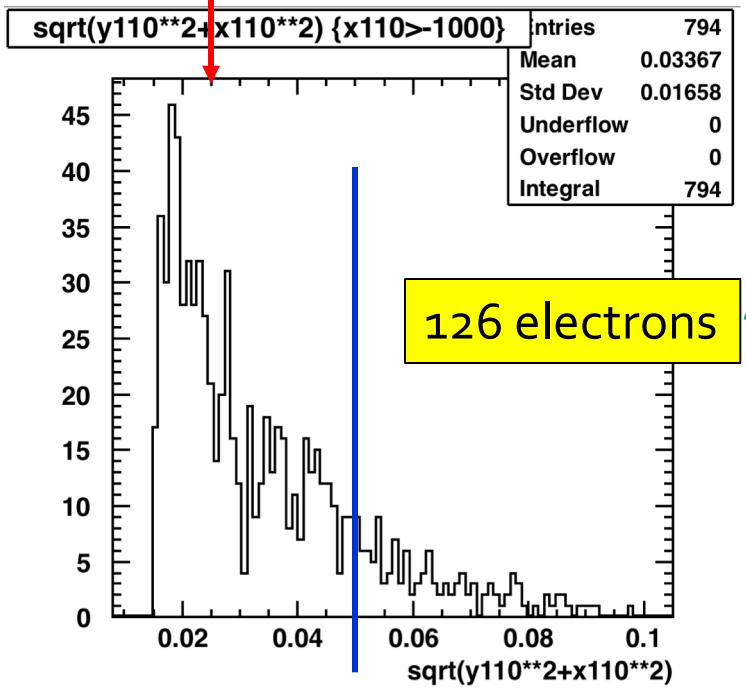




Extrapolate tracks to opposite LumiCal

- 794/1074 (74%) of electrons leave beam pipe before z=1.00 m
- Here is shown the (y,x) positions of these extrapolated to LumiCal at z=1.10 m
- And radius



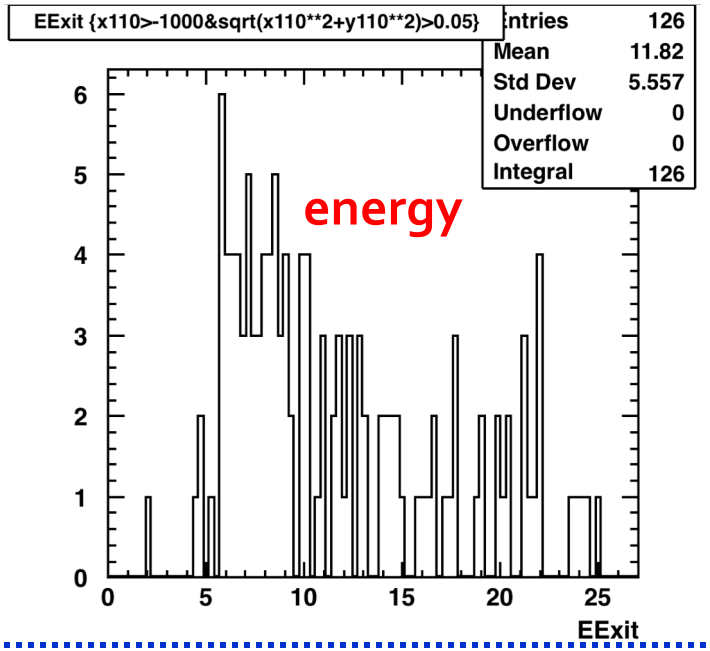


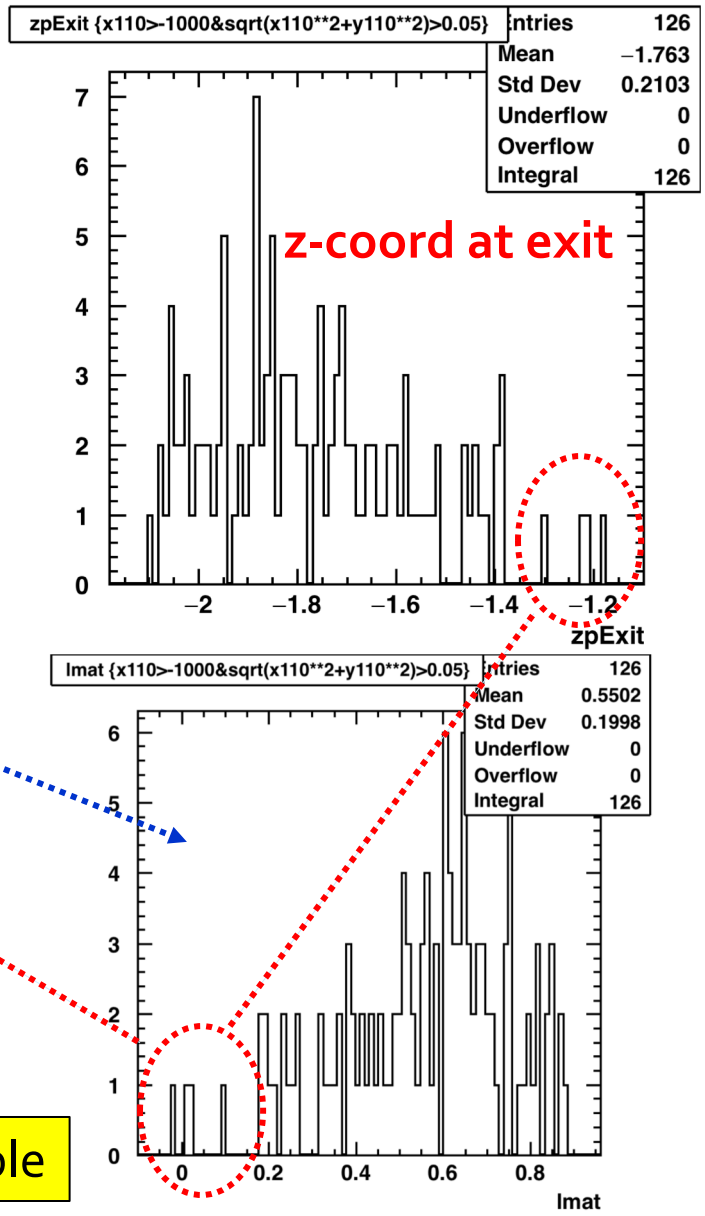
126 electrons

Statistics at this level:

- Prob per BX: 0.005
- Coincidence prob: **2.5 x 10^{-5}**
- Bhabha prob: **6.4 x 10^{-4}**

Tracks above 50 mm on opposite LumiCal





With 15 mm W shielding around Cu beam pipes up to z=-1.2 m, the exiting electrons will traverse through this much material

Probably only these 4 electrons would have a chance to deposit a sizable energy in LumiCal

Statistics at this level:

- Prob per BX: 0.00015
- Coincidence prob: 2.3×10^{-8}
- Bhabha prob: 6.4×10^{-4}

Looks negligible

Outlook

- At LEP, coincidences of off-momentum particles from beam-gas scattering was the dominant background for the luminosity measurement
- A file of such events at FCC-ee has been provided by Oscar Blanco et al.
- At first look, performing simple straight line extrapolation of tracks to the luminometers, this background looks to be negligible
  - Electrons which could potentially reach opposite luminometer [$5x10^{-3}$ per BX] exit th ebeam pipe early (z < -1.1m) and will meet tungsten shielding around beam pipe.
  - Very few [$O(10^{-4})$ per BX] would seem to have a chance to deposit a sizeable energy i opposite calorimeter.
- All of this should of course be chacked with full simulatiom.
- Also need to check of the effect of possible secondary particles on tracker, and on this side luminometer